Assessment of Three Methods for Estimating Abundance of Ungulate Populations

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ABSTRACT The accuracy of three methods (pellet group count, inverse line transect method and track count) for estimating the density of ungulate population was assessed, based on a wapiti population with the known size in the enclosure of 500 hm^2 on Tonghe Hunting Farm, Heilongjiang province, China, during 1992-1993. The estimation of population density using the pellet group count method was the closest to the actual value, whereas the density of the wapiti population was underestimated by the inverse line transect method and overestimated by the track count method. No significant difference existed between the estimated and actual values for the pellet group method and the inverse line transect method, but the significant difference was found for the track count method. Therefore, it is suggested that the pellet group method should be given the priority in the survey of ungulate population abundance in practice.
Key words: Ungulate, Pellet group count, Inverse line transect method, Track count.

Introduction

Estimation of abundance is a basic task in analyzing the dynamics of wildlife population. The information on population abundance is also crucial to scientific management of wildlife. To estimate the density, the accuracy of a method is an important consideration.

Ungulates are relatively large in their body size and often have extensive activity ranges. Some species have seasonal movements (Robel, 1960; Cairns, 1980). Thus, it is a very difficult to accurately estimate the densities of ungulate populations in practice. It is particularly the case in China where most ungulate populations are generally sparse as compared with those of other countries. The line transect method (Gates, 1968; Eberhardt, 1978) and the aerial survey (Caughley, 1974, 1976) were commonly used in North America. Application of these methods, however, were limited in China due to high costs and lower population numbers. Indirect methods based on counts of animal traces such as tracks in snow (Ma and Jia, 1990) and pellets (Neff, 1968), were still given the priority in practice in China. An inverse line transect method was developed by Chen and Chang (1987). The purpose of this paper is to evaluate the accuracy and suitability of those methods applied in China based on a wapiti population with the known size.

Study area

Research work was conducted in an enclosure which covers an area of 500 hm^2 on Heilongjiang Tonghe Hunting Farm during 1992-1993. The enclosure was built up in 1986 and actual number of the wapiti population was 14-16 in 1993 when a direct count was completed by staffs of the hunting farm.

Tonghe Hunting Farm is situated on the southern slope of the Xiaoxing'an Mountains (45° 43'N, 128° 40'E), northeastern China, occupying 30000 hm^2. Tonghe is a low mountain area with an average elevation of 600 m. The weather is continental and characterized by long cold winters, and short hot summers. The annual average temperature is 2.4 ℃ and extreme temperatures range from -40.4 ℃ to 36.7 ℃. The accumulated temperature above 100 ℃ is 2200-2500 ℃. The average annual precipitation is 560-700 mm. The frost-free period (late April to late September) is 100-105 days. Snow accumulates in late November, persisting until end of April, and the average snow depth is 43 cm.

The typical vegetation in the enclosure is the oak forest. Major trees were *Quercus mongolica*, *Populus* spp., *Tilia anmurensis*, *T. mandshurica*, *Fraxinus*

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mandshurica, *Phellodendron amurense*, *Ulmus* spp., *Acer mono* and *Pinus koraiensis*. Understorey shrubs mainly include *Corylus mandshurica*, *Deutzia* spp., *Lonicera* spp., *Syringa amurensis* and *Acanthopanas senticosus*. Common herbaceous layers are *Carex* spp., *Urtica* spp. and *Aegopodium alpestre*.

Methods

Pellet Count

In the late of October 1992, six sampling lines were randomly established in the enclosure, each 500 m long. Ten permanent rectangle plots, each 50 x 4 m^2 in area, were distributed along each sampling line. All old pellets were cleared out from plots while plots were established. In May of 1993, the permanent plots were reexamined by two persons and pellet groups were counted.

To estimate the population density, we used

$$N = \hat{D} \cdot TA / (DR \cdot d)$$

$$\hat{D} = \overline{D} \pm t_\alpha \cdot s / \sqrt{n-1}$$

$$\overline{D} = n_1 / A$$

N: Estimated number of the wapiti population;

$\hat{D}$: Estimates of pellet - group densities (groups/m^2);

$\overline{D}$: Sampling densities of pellet groups (groups/m^2);

TA: The total area of the enclosure (hm^2);

DR: Defecation rate (pellet groups/day);

A: Sampling area (hm^2);

d: The interval between the establishment and the examination of permanent plots (days).

s: Sampling standard deviation;

n: The number of the permanent plots;

n_1: Total number of pellet groups recorded in plots;

The daily defecation rate (DR) was averaged from three adult wapiti (two male and one female), each of which was raised on a fence of 40 m^2, respectively, during the winter of 1992. The counts of pellet groups lasted three days and each count was done in the early morning of each day.

Inverse Line Transect

Twelve sampling strips with length ranged from 1000 m to 2000 m were randomly established in the enclosure in January of 1993, each of which was 30 m wide. The sampling strips were examined by three persons who recorded the perpendicular distances from the pellet groups to the middle lines of sampling strips and counted the number of fresh tracks crossed the sampling strips. The examination of the sampling strips was conducted after second day following snow fall.

The data of perpendicular distance data collected from each sampling strip were grouped (0 - 5 m, 5 - 10 m, 10 - 15 m), and the number of pellet groups in each above data group was transected by a negative exponential·function ($Y = \lambda \cdot e$) as the detective function. The distribution frequency (S_i) of pellet groups was calculated from the following formula:

$S_i = \int_a^b \lambda e^{-\lambda x}$ (a, b are the interval value of each data group)

where x is perpendicular distance and Y is the conditional probability that a pellet group will be found at the given distance. (estimated by $1/\overline{x}$, $\overline{x}$ is the mean perpendicular distance).

f_i, the frequency number of pellet groups in the ith data group after transecting, was calculated from S_i:

$f_i = f_i\,(S_i/S_1)$

The density of pellet groups on each sampling strip was estimated by the following formula.

$D'_j = \sum f'_{ji}/(l_j \cdot w)$ (w is the width of each sampling strip, that is 30 m, l_j: length of jth sampling strip;)

We estimated the pellet group density on the enclosure ($\hat{D}'$) and the variance of $\hat{D}'$(Var($\hat{D}'$)) using D'_j.

$$\hat{D}' = \sum l_j D'_j / \sum l_j = \sum l_j D'_j / L$$

$$\hat{D}' = \hat{D}' \pm t_\alpha (k-1)\sqrt{\mathrm{Var}(\hat{D}')}$$

According to $\hat{D}'$, we can obtain the confidence interval of wapiti population size in the enclosure.

$$TA \cdot (\hat{D}' \pm t_\alpha (n-1)\sqrt{\mathrm{Var}(\hat{D}')}) / (DR \cdot d)$$

Where:

D': density of pellet groups in jth sampling strip;

k: total number of sampling strips;

L: total length of all sampling strips;

TA: total area of the enclosure;

DR: daily defecation rate;

d: days during which pellet groups were counted following the snowfall (here is three days).

Track Count

The date of sampling and the sampling procedure were the same as those of the inverse line transect method. The density of track on each sampling strip (D_j) was estimated by:

$D_j = n_j / (l_j \cdot w)$

And its confidence interval was calculated by:

$$\sum D_j / n) \pm t_\alpha \cdot s\sqrt{n-1}$$

The estimated confidence interval of wapiti population size was

$$TA \cdot (\sum D_j / n \pm t_\alpha \cdot s\sqrt{n-1}) / (F \cdot d)$$

Where,

n_j: number of track on each sampling strip;

l_j : length of each sampling strip;

w: width of each sampling strip;

n: total number of sampling strip;

F: correction factor;

d: days during which tracks were counted following snowfall (here was three days).

Estimation of correction factor The correction factor was used to reduce errors caused by repeated counts of tracks which crossed the sampling strips. This factor can be obtained by tracing one complete track left during day and night. Tracing work was done by two persons, one forward and the other backward, by following a complete animal track on the snow. The course of the track was accurately drawn on the coordinating paper in the scale of 1: 2500. The correction factors were calculated by the following method. Ten random points were located on the coordinating paper and one straight line representing the sampling line which crossed the each of ten random points was turned sixteen times evenly in order that it could cover the whole track. The correction factor can be estimated as the average number that one such straight line cross the track.

Statistical Analysis

Dunnet's many-one statistic was used to test the difference between actual and estimated number of wapiti population (Miller, 1979).

$$t_i = (N_i - N_0 / s \cdot \sqrt{2/n}$$

The threshold value of t_i was $t^{\alpha/2}_{k,(k+1)(n-1)}$ or expressed as $|d|^{\alpha}_{k,v}$

Where:

N_i: estimated number of wapiti population;

N_0: known number of wapiti population (here was 15);

s: standard deviation;

n: Sample size (here was 12).

We treated five permanent plots on each sampling line as one sample in the pellet count method in order to keep the same sample size as that of the inverse line transect method and the line method, and to conduct the simultaneous test for these three methods.

Results

Daily Defecation Rate and Correction Factor

Daily defecation rate was 13.6 ± 1.9 ($t_{0.05}(8)$=2.306), obtained from the continuous observation of three wapiti for three days in winter of 1993.

Correction factor was 2.3 ± 0.3($t_{0.05}(7)$)=2.365), estimated from eight complete day and night tracks obtained in winter of 1993.

Population Density

Estimates of densities of wapiti population in the enclosure using three methods were summarized in Table 1.

Table 1 Estimates of a wapiti population size using three methods in the enclosure on the Tonghe Hunting Farm during 1992-1993

Pellet group count method		Inverse line transect method		Track count method	
Estimated number of population (individuals)	Precision (%)	Estimated number of population (individuals)	Precision (%)	Estimated number of population (individuals)	Precision (%)
19.3 ± 3.5 $t_{0.2}(59)$=1.296	81.8	9.1 ± 6.1$t_{0.2}(11)$=1.363	34.7	33.3 ±6.3$t_{0.2}(11)$=1.363	81.1
s = 13.69 $\|t\|$ =0.769		s = 14.8 $\|t\|$ =0.976		s = 15.289 $\|t\|$ =0.2.932	
		$\|d^{\alpha}_{k,v}\| = \|d^{0.05}_{3,12}\| = 2.41$			

Note: The known number of the wapiti population in the enclosure was 15. The interval between two sampling dates were 205 days for the pellet group method.

The estimate of density (19.3) from the pellet method was the closest to the actual value (15). The densities of wapiti population in the enclosure were underestimated (9.1) by the inverse line transect method and overestimated (33.3) by the track count method (Table 1). Precision for the estimates of densities by the pellet group method and the track count method was much higher (over 80% for both methods) than that by the inverse line transect method (34.7%).

The simultaneous statistical test indicated that no significant difference was found between the estimate of population density and actual value by the pellet count method and the inverse line transect method ($p > 0.05$), whereas significant difference existed between the estimated and actual values by the track count method ($p < 0.05$) (Table 1).

Discussion

Generally, the suitability of a given method to estimate the density of wildlife population depends mainly upon two factors, the accuracy and the simplicity. It is usually easier to use indirect methods in practice, for ungulates. However, the accuracy of the indirect method would be a key consideration.

Pellet Count Method

In our study, the pellet count method was better than other two methods in the accuracy (Table 1). However, more labor work is needed for the establishment and examination of the permanent plots, and a certain interval for the examination of the permanent plots is required. It will be unnecessary to establish the permanent plots only when the time of defecation can be accurately determined. Thus, it will be a big advantage for conducting the survey by using this method after the snowfall, which covers the previous pellet groups completely.

Inverse Line Transect Method

Although no significant difference was found between the estimated and actual values for this method, its statistic precision was much lower than other two methods. A large error in the estimation probably came from the week sampling intensity, which may be a possible reason for no significant difference found between the estimated and actual values. Therefore, further work will be needed to assess the accuracy of this method. Some points should be considered before using this method.

1. It is key to accurately determine the length of the sampling strip which is an important source leading to a huge error of the estimate for the population density. That is a serious problem which is urgently needed to be solved in practice.
2. More work should be done in the determination of the width of the sampling strip and the grouping data of perpendicular distances of pellet groups.
3. A negative exponential function was used as the detection function, but there may exist other better function as the detection function.

Track Count Method

Although this method, due to its simplicity, is commonly used for estimating the ungulate population in China, especially in northeastern China where the snow environment in winter is an advantage for using it, the estimate of wapiti population density by this method in the enclosure was not accepted in the statistical test. The density of wapiti population was seriously overestimated by using this method. Therefore, some serious problems with this method should be considered.

1. The width of the sampling strip determined arbitrarily by the investigators is a huge error for the estimate of population density. For example, the difference between the two estimated values of population density will be enlarged by 10 times when we set 10 m and 100 m for the width of the sampling strip.
2. Like the inverse line transect method, how to accurately determine the length of sampling strip is a serious consideration with this method.

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